This is the SAFT/VALEO Presentation

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* Dr. Menahem Anderman Founded this Conference.

# Ni-MH / Lead Acid Dual battery system :

## A reliable solution for energy demanding vehicles

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## CONTENT

- INTRODUCTION
- TECHNICAL DESCRIPTION
- FINANCIAL APPROACH
- CONCLUSIONS

## INTRODUCTION

- Background
- Vehicle evolution
- Dual battery system concept

## Background : lead acid is reaching its limits...

Most frequent failures in a vehicle are electrical ones

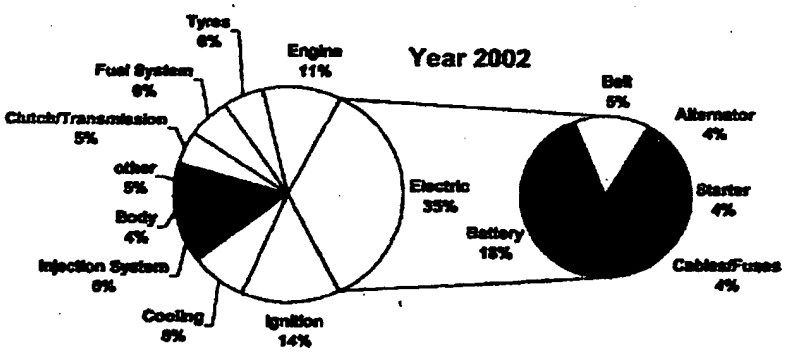
⇩

Among the electrical failures,
50% are related to the lead acid battery

Consequence :
Vehicle stopped !

## FAILURE PARETO

Electrical failures, and more specifically battery failures are the N°1 cause of vehicle failure




Breakdowns statistics compilation from majors automobile associations (ADAC, AA, GIPA, TCS,...)

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## Vehicle evolution : energy consumption still increasing...

- **Booming of "life on board" features**
  - Energy need increases permanently
  - Development of energy demanding features
    - Entertainment : DVD player, GPS...
    - 12V network : Games, tools, heater, *mini-fridge*...
  - Increasing use of these features during idle stop
  - Introduction of vehicle pre-conditioning features
    - pre-heating or pre-cooling functions
    - highly energy demanding functions

Lead acid batteries are more and more deep cycled

- **Introduction of Stop & Go vehicles**
  - Idle stop phases more frequent
  - Increase of energy consumption

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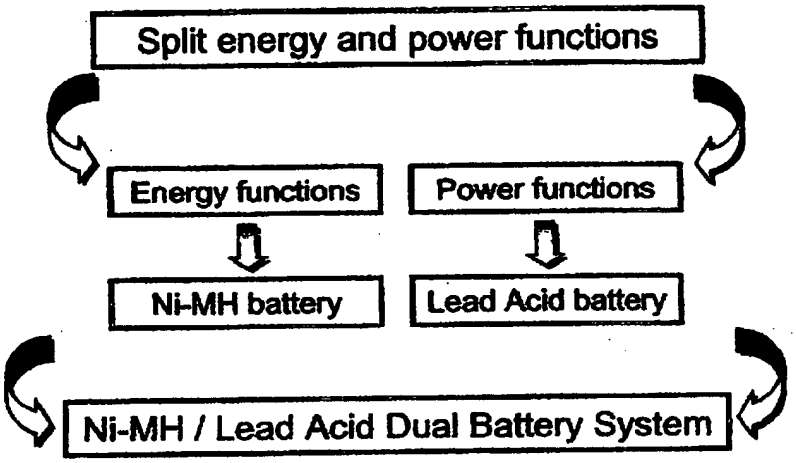
## Dual battery system concept

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## TECHNICAL DESCRIPTION

- **MODEL DATA**
  - Number and type of stops
  - Battery module options
  - Duty cycle profile
  - Temperature profile
- **PROPOSED SOLUTIONS**
  - Ni-MH cell technology
  - Battery module performance
  - Battery module architecture
  - Electronics architecture

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## MODEL DATA :
## Number and type of Stops

- **Assumptions**
  - Annual mileage : 12,500 mile / year
  - Average speed : 25 mile / hour
  - Average distance : 35 mile / day

  } ~500 h / year

- **Types of Stop**
  - Stop / Go : 80 stops / day (7/7)
  - Utility stop : 20 stops / day (5/7)
  - Pre-conditioning : 2 cycles / day (5/7, 3 months / year)
- **Number of Stops**

| Stop type | Stop/Go | Utility | Pre-conditioning |
|---|---|---|---|
| Duration (sec) | | | |
| Number / day | | | |
| Number / week | | | |
| % usage / year | | | |



## MODEL DATA :
## Battery module options

- **Selected onboard features**
  - Data derived from the European SCIWork work team
- **Three 10.8V battery module options**
  - 400 W / 9 Ah
  - 800 W / 12 Ah
  - 1000 W / 15 Ah
- **Example : 400W battery module**

| Power and Energy needs | | | |
|---|---|---|---|
| Features | Power (W) | Energy (Wh) need per stop | Capacity (Ah) need under 10,8 V |
| Electronics | 120,0 | 10,8 | 1,0 |
| Heaters | 10,0 | 0,8 | 0,1 |
| Lamps | 160,0 | 14,5 | 1,3 |
| Motors | 80,0 | 6,9 | 0,6 |
| Others | 30,0 | 3,3 | 0,3 |
| Solenoids | 0,0 | 0,0 | 0,0 |
| TOTAL | 400,0 | 36,3 | 3,3 |

## MODEL DATA :
## Duty cycle profile (1/2)

- **General assumptions**
  - Energy consumption in stop phase only
  - 3 types of vehicle considered
    - Utility vehicle
    - Small vehicle with S&G
    - Large vehicle with / without pre-conditioning
- **Pre-conditioning**
  - Pre-conditioning 3 months / year (1,5 month in summer & winter)
  - Summer : 2 times per day (12 AM and 2 PM) @ 50% power
  - Winter : 2 times per day (8 AM and 6 PM) @ 100% power
- **Stop and Go**
  - Trip duration with S&G :
    21,5 min = 11,5 min driving + 10 min S&G

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## MODEL DATA :
## Duty cycle profile (2/2)

- **Duty cycle per vehicle type**

<table>
<tr><th colspan="2">400W module</th><th>800W module</th><th>1000W module</th></tr>
<tr><td>Without S&G</td><td>With S&G</td><td>Without pre-conditioning</td><td>With pre-conditioning</td></tr>
<tr><td>Utility Vehicle</td><td>Small vehicle</td><td>Large vehicle</td><td>Grand VP</td></tr>
<tr><td>25 min driving<br>5 min stop</td><td>21,5 min driving<br>20 stops S&G</td><td rowspan="2">Standard profile<br>2 h @ 70W / day, 1 day / week<br>10 months / year</td><td>10 min pre-conditionning<br>21,5 min driving</td></tr>
<tr><td>8 times<br>in the morning</td><td>3h rest</td><td>3h rest</td></tr>
<tr><td></td><td>21,5 min driving<br>20 stops S&G</td><td rowspan="2"></td><td>21,5 min driving</td></tr>
<tr><td>1h rest</td><td>1h rest</td><td>1h rest</td></tr>
<tr><td rowspan="2">25 min driving<br>5 min rest</td><td>21,5 min driving<br>20 stops S&G</td><td rowspan="3">Specific profile (vacation)<br>2 h @ 70W / day, 3 days / week<br>2 months / year</td><td>21,5 min driving</td></tr>
<tr><td rowspan="2">4h rest</td><td>4h rest</td></tr>
<tr><td>12 times<br>in the afternoon</td><td>10 min pre-conditionning<br>21,5 min driving</td></tr>
<tr><td></td><td>21,5 min driving<br>20 stops S&G</td><td></td></tr>
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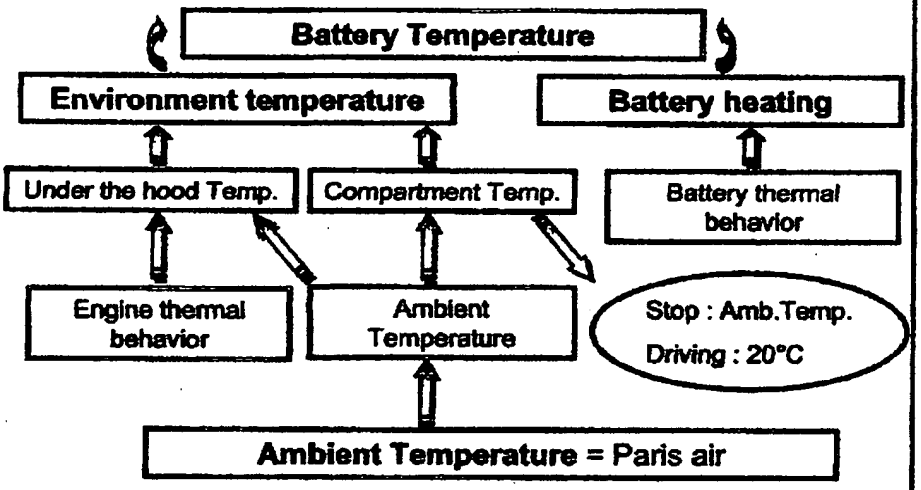
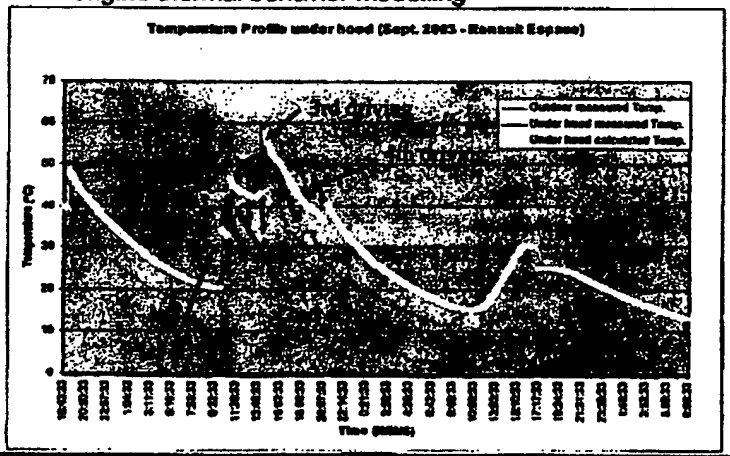
## MODEL DATA : Temperature profile (1/3)




## MODEL DATA : Temperature profile (2/3)

- **Under the hood temperature**
  - engine thermal behavior modelling



## MODEL DATA :
## Temperature profile (3/3)

- **Battery temperature**

Battery thermal behavior modelling :

$$T_{battery} = f(T_{battery-1}, T_{environment}, Battery\ Coefficient)$$

| Battery Configuration | 9S1P | 9S2P |
|---|---|---|
| | Battery Coefficient | |
| Battery w/o casing | 1 | 1 |
| Battery with casing | 0,7 | 0,4 |
| Battery with casing / cooler | 1,2 | 1,2 |

Example :

9S2P w/o casing

Battery configuration and location determine the battery temperature ⇨ Life duration

## PROPOSED SOLUTIONS :
## Ni-MH cell technology

A customized Ni-MH technology

- **Saft VHT product range :**
  - Initially designed for ELU applications
    - Saft ➔ WW leader (70% market share)
  - With unique features :
    - Energy applications
    - High temperature environment (40~50°C)
    - Long life duration (>8 years @ 40°C)
  - Product range :
    - VHT AA 1 Ah / available
    - VHT Cs 2 Ah / available
    - **VHT F 10 Ah / Q1'05 commercial launch**

## PROPOSED SOLUTIONS :
## Battery module performance

| | 400W module | | 600W module | 1000W module |
|---|---|---|---|---|
| | Without S&G | With S&G | Without S&G | Without S&G |
| | Utility vehicle | Small vehicle | Large vehicle | Large vehicle + Pre-cond. |
| Battery configuration | 9S1P<br>1 layer 3x3 | 9S1P<br>1 layer 3x3 | 9S2P<br>2 layers 3x3 | 9S3P<br>3 layers 3x3 |
| Ni-MH cell type | VHT F | VHT F | VHT F | VHT F |
| Battery capacity | 9 Ah | 9 Ah | 18 Ah | 27 Ah |
| capacity used | 3 Ah | 0.3 Ah | 12 Ah | 15 Ah |
| SOC | 35% | 3% | 65% | 55% |

| Battery (with cooling) location | compartment | compartment | compartment | under the bed | compartment | under the bed |
|---|---|---|---|---|---|---|
| Battery cooling | | | | | | |
| driving + stop (S&G) phase | yes | yes | no | no | no | no |
| stop phase | yes | no | no | no | no | no |
| Temperature increase | +14°C<br>(1 driving) | +30°C<br>(20 days) | +6°C<br>(per day) | +6°C<br>(per day) | +20°C<br>(per day) | +20°C<br>(per day) |

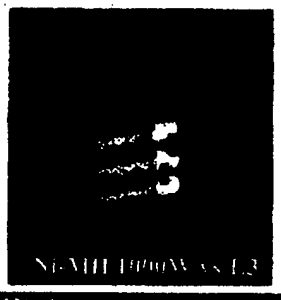
| Battery environment | Calculated battery life duration | | | | | |
|---|---|---|---|---|---|---|
| Parts air cooling driving and rest | 6 years | 5 years | 10 years | / | 9 years | / |
| Parts air cooling rest and cabin air cooling driving | 5 years | 4 years | 8 years | / | 7 years | / |
| Under the hood air | / | / | / | 7 years | / | 6 years |



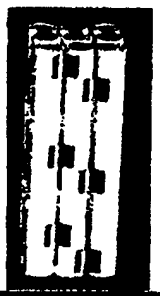
## PROPOSED SOLUTIONS :
## Battery module architecture

Ni-MH versus Lead-Acid

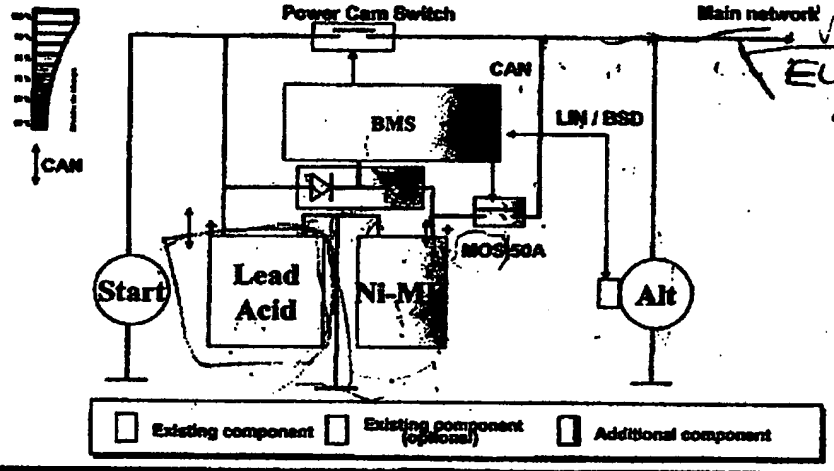
| Battery module | Lead-acid (12V - 55 Ah) | Ni-MH 400W (10,8V - 9 Ah) | Ni-MH 600W (10,8V - 18 Ah) | Ni-MH 1000W (10,8V - 27 Ah) |
|---|---|---|---|---|
| Dimensions | L3 | | | |
| L : W : H (mm) | 278 : 175 : 190 | 270 : 37 : 105 | 270 : 68 : 105 | 270 : 105 : 105 |
| Volume (l) | 9,2 | 1,0 | 2,0 | 3.0 |
| Weight (kg) | 18,0 | 2,5 | 5,0 | 7,5 |







## PROPOSED SOLUTIONS :
## Electronics architecture

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## FINANCIAL APPROACH

- **Ball park pricing for 400 W, 800 W and 1000 W modules**

PROJECTED PRICING

| Battery module type | 400 W module | | 800 W module | | 1000 W module | |
|---|---|---|---|---|---|---|
| Annual quantities | 10 K | 100 K | 10 K | 100 K | 10 K | 100 K |
| Battery price : | | | | | | |
| € | 85 | 75 | 160 | 140 | 240 | 210 |
| € / kWh | 874 | 772 | 823 | 720 | 823 | 720 |
| Electronics price : | | | | | | |
| € | 40 | 25 | 40 | 25 | 40 | 25 |
| Total System price : | | | | | | |
| € | 125 | 100 | 200 | 165 | 280 | 235 |